CLAIMS

While the invention has been described with reference to particular example embodiments, further modifications and improvements which will occur to those skilled in the art, may be made within the purview of the appended claims, without departing from the scope of the invention in its broader aspect.
Numerous modification and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

What is claimed is:

1. A noise filtering edge detector (NFED) for removing phase noise from wave-form edges and/or removing amplitude glitches from wave-form pulses by continues digital filtering of the entire incoming wave-form sampled in time instances matching single gate delays provided by outputs of a delay line built with serially connected gates which a sampling clock is propagated through, wherein variable lengths pulses having frequencies ranging from zero to 1/2 of technology's maximum clock frequency are processed by comparing an edge mask, which provides an expected pattern of wave-form samples corresponding to an edge of the wave-form, with a sequence of wave-form samples surrounding a consecutive analyzed sample; the NFED comprising:

a wave capturing circuit for capturing results of sampling the incoming wave-form in time instances produced by the outputs of the delay line which the sampling clock is propagated through;

means for performing logical or arithmetic operations on particular samples of the edge mask and their counterparts from the wave-form samples surrounding the consecutive analyzed sample of the captured wave-form;

means for using the results of said operations for deciding if said operations can determine a filtered location of an edge of a filtered wave-form.

2. An NFED as claimed in claim 1, wherein said edge mask samples of the expected edge pattern are compared with samples from a consecutive processed region of the captured wave-form wherein correlation between a consecutive edge mask sample and a corresponding sample from the processed region is estimated by performing an arithmetical or logical operation on said consecutive mask sample and on said corresponding sample from the processed region; the NFED comprising:

means for accessing any said consecutive processed region of the captured wave-form and using such region as comprising samples corresponding to the edge mask samples;

means for selection of a consecutive sample from the edge mask and for simultaneous selection of a corresponding consecutive sample from the processed region of the captured wave-form;

means for calculating a correlation component between such selected samples by performing an arithmetical or logical operation on said selected samples;

means for calculating a digital correlation integral by adding said correlation components calculated for single samples of the edge mask.

3. An NFED as claimed in claim 2, wherein said correlation integrals are calculated for said consecutive processed regions uniformly spread over all the captured wave-form wherein said calculated correlation integrals are further analyzed and locations of their maximums or minimums are used to produce said filtered locations of said edges of the filtered wave-form; the NFED comprising:

means for moving said processed region by a programmable number of samples positions of the captured wave-form;

means for storing and comparison of said correlation integrals calculated for different processed regions, in order to identify said maximums or minimums and their locations;

means for using said locations of said maximums or minimums for producing the filtered locations of the edges of the filtered wave-from.

4. An NFED as claimed in claim 3, wherein noise is filtered and said storing and comparison of said correlation integrals are simplified by subtracting an edge threshold from any newly calculated correlation integral first and by disregarding all resulting decreased integrals if they are negative while using only positive decreased integrals for further noise filtering; the NFED further comprising:

means for subtracting the edge threshold from any newly calculated correlation integral, in order to determine if such decreased integral indicates signal change greater than noise levels and to reduce amount of further processing;

means for dismissing those said decreased integrals which have negative values, and for classifying only those said decreased integrals which are still positive for a further signal processing including said comparisons.

5. An NFED as claimed in claim1, wherein the NFED further comprises:

a filter arithmometer for comparing the edge mask with the captured wave-form in order to introduce noise filtering corrections of the edges of the filtered wave-form;

a filter mask register providing the edge mask which is compared with the captured wave-form of an input signal and/or filter control register which provides code for controlling operations of said filter arithmometer in order to provide said corrections of the filtered wave-form.

6. A noise filtering edge detector (NFED) as claimed in claim1, wherein the NFED includes compensation of inter-symbol interference (ISI) or other predictable noise by adding a programmable displacement to said filtered location of the edge of the wave-form; the NFED comprising:

means for programmable amendment of the filtered location of the wave-form edge by presetting said programmable displacement with a new content;

means for using such newly preset displacement for shifting the filtered location of the next detected edge.

7. A noise filtering edge detector (NFED) as claimed in claim1, wherein the NFED uses a set of binary values as the edge mask which is compared with a set of captured binary values surrounding the analyzed sample of the captured wave-form in order to produce an edge proximity figure (EPF) estimating a proximity of the analyzed sample to a

nearest wave-form edge wherein the EPF is further compared with an edge threshold in order to detect if the analyzed sample can point out location of an edge of the filtered wave-form; the NFED comprising:

means for using the results of said operations for producing the edge proximity figure (EPF) estimating a mismatch between said nearest edge and the wave-form region surrounding the analyzed sample;

means for comparing the EPF with the edge threshold, in order to determine if the analyzed sample provides said location of an edge of the filtered wave-form.

8. A noise filtering edge detector (NFED) as claimed in claim 7, wherein the NFED further includes compensation of periodical predictable noise with programmable modulations of said filtered locations of the wave-form edges by using an edge modulating factor (EMF) for a periodical diversification of said edge thresholds corresponding to different said regions of the wave-form; the NFED comprising::

means for modulation of the filtered locations of the wave-form edges by using the edge modulating factor (EMF) for modulating said edge thresholds which are used for the evaluation of the EPF's calculated for said different wave-form regions surrounding different consecutive samples of the captured wave-form;

whereby said EMF provides such modulation of the edge thresholds, that predictable noise introduced to consecutive wave-form samples by known external or internal sources, is compensated.

9. A noise filtering edge detector (NFED) as claimed in claim 8, wherein:

said modulation of the edge thresholds is controlled by an edge modulation control register (EMCR) which is preset by an external control unit.

10. An NFED as claimed in claim 1, wherein the NFED comprises:

sequential processing stages configured into a sequential synchronous pipeline driven synchronously with said sampling clock.

11. An NFED as claimed in claim 10, further comprising parallel processing phases implemented with said synchronous sequential pipelines; wherein:

said parallel processing phases are driven by clocks having two or more times lower frequencies than said sampling clock;

consecutive parallel phases are driven by clocks which are shifted in time by one or more periods of said sampling clock;

12. An NFED as claimed in claim 11, wherein:

said wave-form filtering is extended beyond a boundary of a single phase by using multiple noise filtering sequential stages in every parallel processing phase.

13. An NFED as claimed in claim 12, including an over-sampled capturing of consecutive wave-form phases in corresponding phases wave registers which are further rewritten to wave buffers with overlaps which are sufficient for providing all wave samples needed for a uniform filtering of any edge detection despite crossing boundaries of the wave buffers which are loaded and used during different said phases; the NFED comprising:

means for rewriting the entire wave register belonging to one phase into the wave buffer of the same phase and for rewriting an end part of said wave register into a front part of the next phase wave buffer, while the remaining part of the next wave buffer is loaded from the wave register belonging to the next phase;
whereby every wave buffer contains entire said wave-form regions needed for calculating said EPF's corresponding to the samples belonging to the phase covered by this buffer.

14. An NFED as claimed in claim 12, wherein:
carry over bit or bits of an output register of a first filter stage of one phase is or are clocked-in into an output register of the first filter stage of a next phase together with filtering results of the next phase;
a second filter stage of the next phase uses the output register of the first filter stage for filtering a wave-form interval which extends into the next phase.

15. An NFED as claimed in claim 12, comprising:
means for merging of said parallel processing phases, wherein multiple said parallel processing phases are merged into a smaller number of parallel phases or into a single processing phase, when passing from one said sequential processing stage to the next sequential stage.

16. An NFED as claimed in claim 12, comprising:
means for splitting of said parallel processing phases, wherein one said processing phase is split into multiple parallel processing phases or multiple parallel processing phases are split into even more parallel phases, when passing from one said sequential processing stage to the next sequential stage.

17. An NFED as claimed in claim 12, further including a programmable control unit (PCU) for reading results of captured signal processing from the NFED and for controlling operations of the NFED; wherein the PCU comprises:
means for reading results of captured signal processing from the NFED;
means for programming the filter mask register and/or the filter control register and/or said presetting of the programmable displacement and/or the edge modulating factor, which are applied for achieving said filtering of the captured wave-forms.

18. An NFED as claimed in claim 1, further including a programmable control unit (PCU) for reading results of captured signal processing from the NFED and for controlling operations of the NFED; wherein the PCU comprises:

19. An NFED as claimed in claim 1, further including a wave-form screening and capturing circuit (WFSC) for incoming waveform registration and monitoring wherein the WFSC identifies characteristics of the incoming wave-form captured with the resolution matching single gate delays; wherein the WFSC comprises:
means for using programmable screening masks and/or programmable control codes for verifying incoming wave-form captures for compliance with said programmable

screening masks.

20. An NFED as claimed in claim 19, wherein the WFSC comprises:
means for buffering captured wave-form for which the pre-programmed compliance or non-compliance has been detected, or for counting a number of said detections;
means for communicating said buffered wave-form and/or a detections counter, to an internal control circuit and/or to an external unit.

21. An NFED as claimed in claim 20, further including a programmable control unit (PCU) for reading results of captured signal processing from the WFSC and for controlling operations of the WFSC; wherein the PCU comprises:
means for programming the screening masks and/or the control codes for performing said verification of captured wave-forms compliance or non-compliance with said screening patterns;
means for reading verification results and/or reading captured wave-forms which correspond to the preprogrammed verification criteria.

22. An NFED as claimed in claim 21 including implementation of adaptive noise filtering algorithms; wherein the PCU comprises:
means for programmable waveform analysis;
means for loading edge mask registers which provide said edge masks used for detecting rising and/or falling wave-form edges;
or means for loading edge threshold registers which provide said edge thresholds used for detecting rising and/or falling waveform edges;
or means for loading edge displacement registers which provide said edge displacements used for shifting detected rising and/or falling edges by a programmable number of samples positions of the captured wave-form;
or means for loading filter control registers which control said logical and/or arithmetic operations conducting the comparison of captured wave-form samples with the edge mask, and said edge displacements in the processed wave-forms;
or means for controlling said EMF by presetting the EMCR in accordance with adaptive noise filtering algorithms.